

Feature Extraction of Tooth Morphology for Human Identification

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ABSTRACT:

Forensic dentistry is one of the branches of forensic science that identifies people based on their dental records. These records are mainly available as a radiograph images. In this paper we present the basics of computerizing the process of enhancing and extracting the features of dental radiograph image and finally the identification of human beings. Given a postmortem (PM) radiograph dental record, we have to search the database of antemortem (AM) radiographs to determine the identity of the person based on some features. Here we first apply contrast stretching enhancing technique to the radiograph to get the best feature for matching. The proposed method extracts the crown contour (CC) of the individual tooth by using a probabilistic approach based on pixel intensities. Enhancement of the poor quality radiograph image improves the result promisingly.

Keywords: Forensic dentistry, Dental radiographs, Segmentation, Human identification, Image enhancement, Crown contour (CC)

INTRODUCTION

Forensic dentistry aims towards the proper handling, examination and evaluation of dental evidence, which will be then presented in the interest of justice. The main reason for identifying human beings through dental images come into picture because of the other biometric identification like fingerprint, face, iris etc. are not properly determined. The bodies of victims of violent crimes, fires, motor vehicle accidents and work place accidents, can be disfigured to such an extent that identification by a family member is neither reliable nor desirable. Persons who have been deceased for some time prior to discovery and those found in water also present unpleasant and difficult visual identifications. Dental identifications have always played a key role in natural and manmade disaster situations.

The method presented in this paper is to automate the process of forensic dentistry by extracting more efficient features from highly enhanced radiograph images. For human identification through dental radiograph images is done based on two types of dental radiograph images antemortem (AM) and postmortem (PM) images respectively (Fig.1). The radiograph images that are collected while the person is alive are called AM images and the radiograph images collected after death are called PM images. The AM images are first collected in a database and labeled with unique identification code. The approach for human identification is to match the PM radiographs of unidentified person against the database of AM images. If there is a positive match between the query PM image of tooth and the database AM image of tooth, then the identity of the deceased person is found.

Formerly when the AM and PM dental radiograph images were compared manually by the forensic experts it is too complex procedure and too much time

consuming. This is done based on a systematic dental chart prepared by some forensic experts. In this dental chart, a number of distinctive features of individual tooth are noted. These features are the different properties of the teeth (e.g., tooth present/not present, crown and root morphology and dental restorations), periodontal tissue features, and anatomical features. Forensic experts confirm or reject the identity based on the number of matches between the two dental charts prepared from the AM and PM images. The process of human identification based on dental radiograph images is complicated because unlike other biometric characteristics (e.g., fingerprints, iris, etc.), dental features changes over time. But in certain cases as discussed above this is the only available biometric method for identification and it is accepted in a court of law.

For the automated identification several authors have proposed different approaches. But the main problem is the qualities of the images are too poor to extract features in a proper way so that the identification is positive. There for in this paper our main objective is to first enhance the poor quality radiograph image by increasing the contrast of the tooth and then from that enhanced image CC feature is extracted and stored in the database for matching. Here we have divided the whole system into four parts-first, Enhancement of the dental radiograph image, second segmentation of the radiograph image to find the individual tooth, third is to extract the crown contour (CC) using the probabilistic approach based on the pixel intensities, and finally the shape matching phase. Previously many authors extracted the shape of the individual tooth using the edge detection method. However due to substantial noise that present in radiograph images, the edge-detection method does not gives us proper result in all the AM images in the database.

PROPOSED SYSTEM

The proposed system will do the task of forensic expert more easily and accurately. With this automatic identification system the tedious job of making dental charts of distinctive features for each of the 32 teeth will be reduced. This identification system will consume less time for the extraction of CC feature and for the matching between the AM and PM images. Here in this system, unlike the previous ones we have focused on the enhancement phase also. First of all the enhancement module of the system enhanced the contrast of the poor quality radiograph image using the contrast stretching method. From this Enhanced image individual tooth were extracted using the semi automated gap valley technique. Gap valley also helps us to automatically select the ROI (Region of Interest) and the crown center. In this system we simplify the matching of the tooth shape by using only the crown's shape that is the CC feature. A logical diagram of the automatic dental identification system and the processing flow within the system is shown in Fig.2.and Fig.3 respectively.

Enhancement

The enhancement process for dental radiograph image is to produce high quality improved dental radiograph image from a degraded dental radiograph image. In this phase of the system we first convert the RGB image to gray scale image. This is the preprocessing phase in enhancement stage. Reducing an image to gray scale from color image is a very simple task, just to take the green value and use, and apply the same value in place of red and blue also.

Since, dental radiographs contain three distinctive regions: background, teeth, and bones. Usually the teeth regions have the highest intensity, the bone regions have high intensity that sometimes is close to that of the teeth, and the background has a distinctively low intensity. It is easy to separate the background by threshold-based methods, but these methods usually fail to discriminate teeth from bones.

Previously some author used the Adaptive histogram equalization method that computes the histogram of a local window centered at a given pixel, to determine the mapping for that pixel, for contrast enhancement of the image. However, the results of this approach not always good for CC feature extraction.

Here we have used the method of contrast stretching by using gray level intensity transformation function. The result of this technique is better then the previous histogram equalization technique. This method is one of the spatial domain techniques that operate directly on the pixels of an image. In Fig.4 we have shown the result of enhancement after applying our method. The original radiograph image and its histogram is shown

in (a), the result after applying intensity transformation function is shown in (b).

Segmentation

After Enhancement the enhanced image is segmented to get the individual tooth. In this stage, the radiograph image is segmented using the gap valley detection method. Every segmented block contains a individual tooth. This method also helps us to define the ROI associated with every tooth. Here we are mainly worked with two types of dental radiograph images Bitewing and Perapical respectively. For Bitewing we have to find the gap valley between the upper jaw (maxillary) and the lower jaw (mandibular) teeth in the image. After the lower and upper teeth are separated, each tooth to be isolated from its neighbors to get the CC feature.

Gap valley detection

The gap between the two jaws caused a valley in the y axis projection histogram. This gap is detected using the below algorithm.

Step-1 Sum the intensities of pixels along each row parallel to the X-axis.

1.2 Let, y'' is the estimated gap between the upper and lower jaws.

v_i , is the valleys detected in the projection histogram, where $i=1,2,...,m$

D_i , is the depth of v_i

y_i , is the position of gap valley v_i

1.3 Calculate the probability $P_{vi}(D_i) = c(1 - D_i/\max_k D_k)$
Where, c is the normalizing constant.

1.4 Calculate the probability

$$P_{vi}(y_i) = 1/(2\pi\sigma)^{1/2} e^{-(y_i - y'')^2 / \sigma^2}$$

Where, σ is the user initialization error factor.

1.5 Calculate, $P_{vi}(D_i, y_i) = P_{vi}(D_i) P_{vi}(y_i)$

1.6 If y'' is given, v_i is the gap valley at y_i is $\max [P_{vi}(D_i, y_i)]$

In Fig.5 we have shown one of the examples for gap valley detection. From this position of the valley, the upper and lower tooth is separated.

Tooth isolation

After gap valley detection the individual tooth from each jaw is separated. This step uses the same algorithm used for gap valley detection.

In tooth isolation for the upper teeth, we sum the intensities of all the pixels in each line perpendicular to the gap valley. The gaps between the neighboring teeth creates valley and this valleys are detected using the previous gap valley detection algorithm. But in this case the intensities are summed along y-axis. By using the similar procedure the lower tooth is segmented into individual teeth. Here the image quality is improved due to the enhancement of the images so there would be no error regarding over or under segmentation.



Fig.1. (a) Postmortem (PM) and Antemortem (AM)



Fig.1. (b) dental radiograph of the same person.

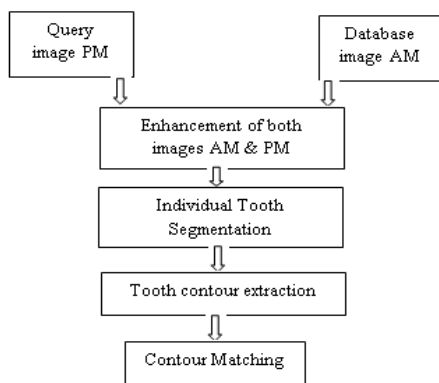


Fig.2. Logical diagram of the human identification system

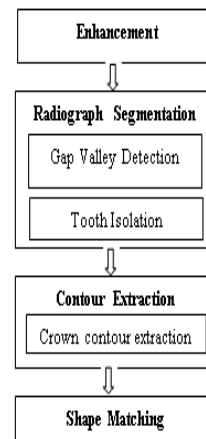
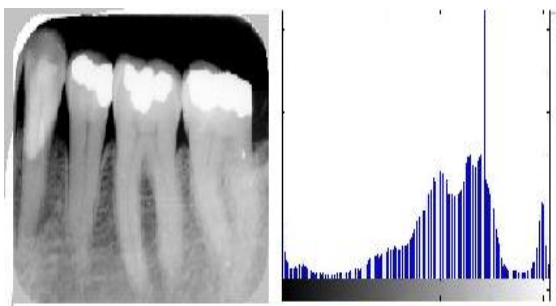
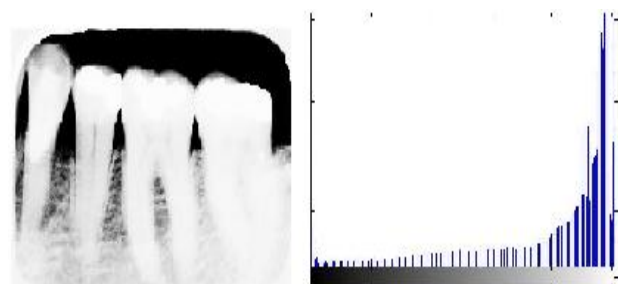


Fig.3. Diagram of the processing flow



(a) Original image and corresponding gray scale histogram.



(b) Enhanced image and corresponding Gray scale histogram.

Fig.4.Image enhancement by contrast stretching using intensity transformation function.

The segmented individual area that holds individual teeth is our ROI (Region of Interest). This is an rectangle and a point inside this ROI at one third of its length and half from other two sides is considered to be as the crown centre C. This point is used for CC feature extraction (Fig. 6).

Crown Contour (CC) feature extraction

Every tooth is having two parts: the upper part is called crown, which is above the gum line, and the lower part is called root, which sits in the bone below the gum line (Fig. 6). But the root of the tooth is not clear in

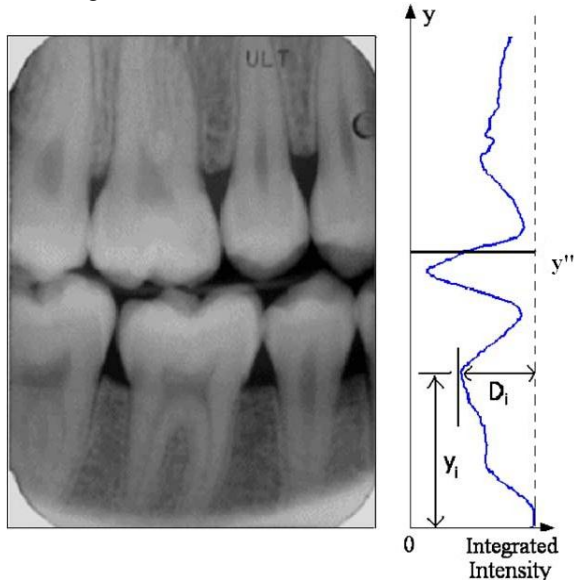


Fig.5 Integral projection on the y-axis

find the most possible boundary point. The probability for a point p to be a boundary point is defined as:

$$P_B(p) = P(w_b | I_{outer}) P(w_t | I_{inner}),$$

Where I_{inner} and I_{outer} are the intensity distribution of the neighbor points of p , p_{outer} and p_{inner} as shown in fig.7.

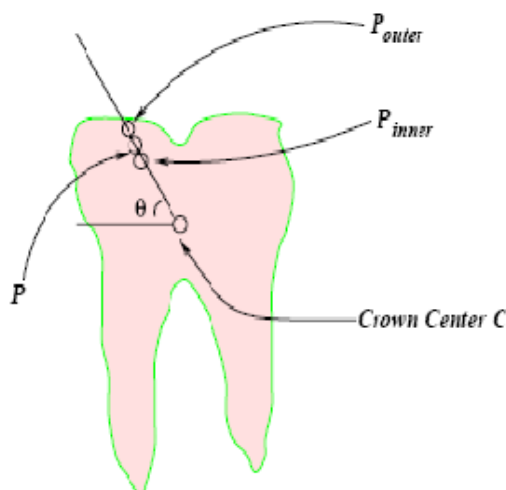


Fig. 7 Extraction of CC feature.

radiograph image because of the bone and the soft tissues. There fore we concentrated on the crown of contour of the individual tooth. The CC feature is extracted by drawing radial lines from the crown centre at different seven angels ($\Theta=0^\circ, 30^\circ, 60^\circ, 90^\circ, 120^\circ, 150^\circ$, and 180°). There are two different classes of pixels in the crown area the tooth pixels w_t is having the highest intensity and the background pixels w_b having the lower intensity than the tooth. First we find the probability for these pixels. Then in each radial line through the crown centre C in different six angels, we

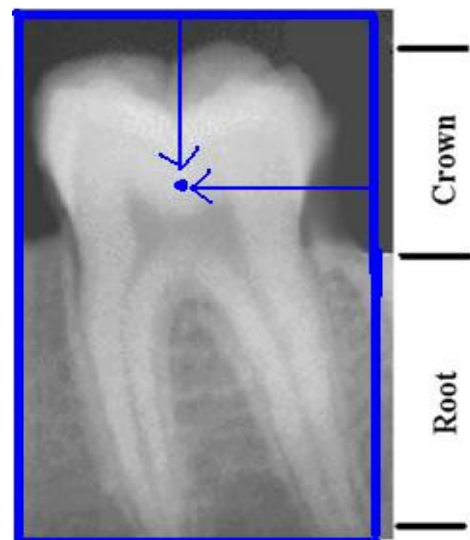


Fig.6 The Region of interest and Crown centre C.

Here we have extracted the CC feature based on the six points, therefore it will extract this points very quickly compare to the previous method and these points are connected to get the proper CC shape for matching phase.

In this system for all the database images these features are extracted and stored in the feature database so that the matching is done more rapidly.

Matching

The CC extracted from the query image is matched with the CC feature extracted and stored in the feature database. One of the main difficulty in matching phase is the query images are taken long time after the database images. So the query images can be rotated or different in size or translated. In order to be able to compare the two shapes an affine transformation must be used before shape matching. After using this transformation the CC feature becomes comparable using an index called matching distance (MD). MD is the sum of the distance between each pair of points in the pair of radiograph images. Then the ranking of images is done based on the matching distance between the query and the database images. The smallest MD becomes the best retrieval image and from that we can identify the corresponding subject.

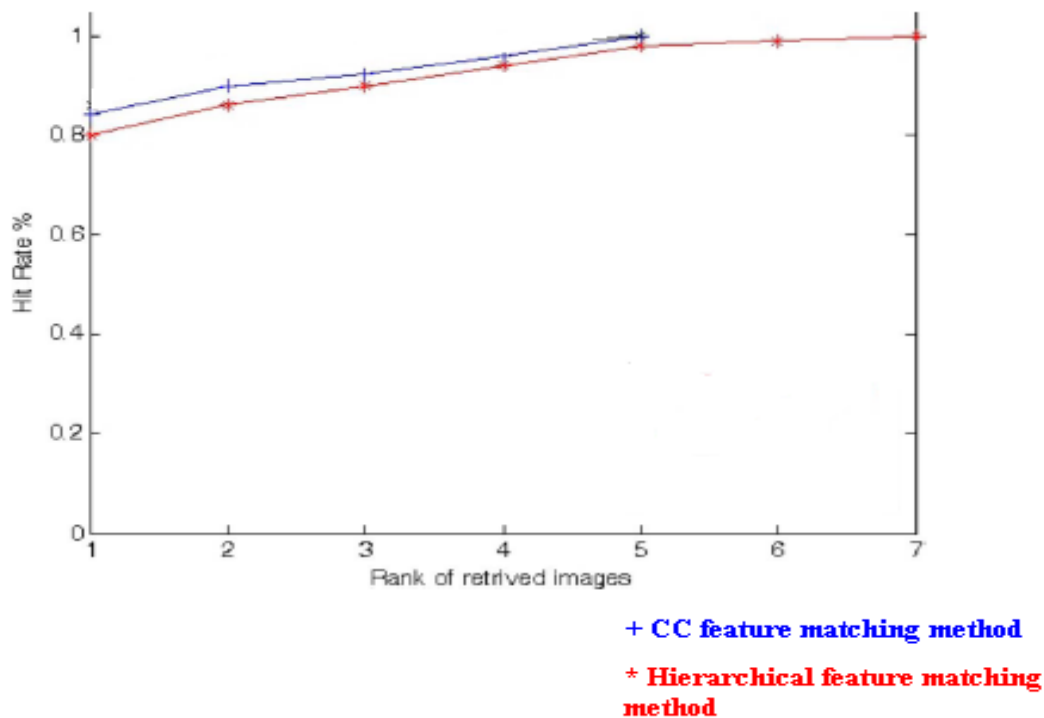


Fig.8 Comparison graph between CC feature and Hierarchical feature.

EXPERIMENT AND RESULT

The proposed human identification system based on dental radiograph images has been applied to 20 images for retrieval from a database of 62 AM images. Because of the lacking of real AM and PM images, the system has been tested for manually modified images. The application is developed using Matlab R2008a and MySQL database for the image and CC feature database. And this application is tested on a Pentium

IV 3.0 GHz computer. Each PM image was rotated, translated or the image scale was changed. In this system first the dataset of dental images are stored by using the CC extraction method. Then for each query images, it is at first enhanced for proper CC feature extraction and then this feature is matched using the matching process. The comparison is made teeth to teeth in each database images and the best or the smallest MD value is retrieved the below graph shows our result which is far better than the previous methods and the time complexity is very low.

Among the 20 query images 16 correctly retrieved and the other 4 images are not correctly matched because of the blurred images, so the teeth shapes were partially visible. From fig. 8 we can say that the our method of extracting the CC feature and match this feature for retrieval from each image gives us better result than previous authors hierarchical contour extraction method. This method is also best in time

complexity because of its less execution time for CC feature extraction.

CONCLUSION AND FUTURE WORK

In this paper we proposed a system for human identification by efficient CC feature of dental radiograph images. This proposed system overcomes the problem of poor quality of radiograph image because the contrast stretching intensity transformation enhancement method gives us promising result. The experimental result show that this method is less time consuming and more accurate then the previous method because of CC feature extraction and matching using the MD method.

This system is tested on a small database and our future work is concern to test the system with a large collection of dataset. In future we want to extract more efficient feature for the better retrieval.

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